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(71)Applicant : TOSHIBA CORP
SHOWA DENKO KK

(72)Inventor : OGIWARA HIDEO
HIKOSAKA KAZUYUKI
OIKAWA SOICHI
SAKAI HIROSHI
SHIMIZU KENJI

(54) PERPENDICULAR MAGNETIC RECORDING MEDIUM AND PERPENDICULAR MAGNETIC RECORDING AND REPRODUCING APPARATUS

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a perpendicular magnetic recording medium low in noise and capable of performing a high density recording.

SOLUTION: The perpendicular magnetic recording medium has a layer showing super-paramagnetism as a base layer.

LEGAL STATUS

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[Patent number]

[Date of registration]

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] It is the vertical-magnetic-recording medium characterized by consisting of layers the aforementioned ground film indicates superparamagnetism to be in the vertical-magnetic-recording medium possessing a nonmagnetic substrate, the ground film formed on this nonmagnetic substrate, and the perpendicular magnetic layer formed on this ground film.
[Claim 2] The layer which shows the aforementioned superparamagnetism is a vertical-magnetic-recording medium according to claim 1 characterized by consisting of particles of the soft magnetic materials which show superparamagnetism.
[Claim 3] The layer which shows the aforementioned superparamagnetism is a vertical-magnetic-recording medium according to claim 1 characterized by having the granular structure by which the particle of the soft magnetic materials which show superparamagnetism in a nonmagnetic base material was distributed.
[Claim 4] The layer which shows the aforementioned superparamagnetism is a vertical-magnetic-recording medium given in the claim 1 characterized by having saturation magnetization below by impression magnetic field 3950 A/m (50Oe), and not saturating magnetization below with impression magnetic field 790000 A/m (10000Oe) to order to the order for 10 to 8 seconds equivalent to recording head magnetic field reversal time 1 second or more, or any 1 term of 3.

[Claim 5] The layer which shows the aforementioned superparamagnetism is a vertical-magnetic-recording medium given in the claim 1 characterized by for magnetic properties showing [temperature T] a soft magnetism or less by 10K, and magnetic properties showing a paramagnetism near ordinary temperature, or any 1 term of 3.
[Claim 6] For the layer which shows the aforementioned superparamagnetism, temperature T is impression magnetic field 790000 A/m (10000 Oe) near ordinary temperature. Magnetization is not saturated below and it is impression magnetic field 3950 A/m (50 Oe) or less in 10K. Vertical-magnetic-recording medium given in the claim 1 characterized by having saturation magnetization below, or any 1 term of 3 and 6.
[Claim 7] The vertical-magnetic-recording regenerative apparatus characterized by providing the following. Vertical-magnetic-recording medium Driving means which support and drive [rotation] the aforementioned vertical-magnetic-recording medium The magnetic head which has an element for performing the element for recording information to the aforementioned vertical-magnetic-recording medium, and recorded informational reproduction It is the perpendicular magnetic layer formed on the ground film which consisted of layers which the carriage assembly which supported the aforementioned magnetic head free [movement] to the aforementioned vertical-magnetic-recording medium is provided, and the aforementioned vertical-magnetic-recording medium is formed on a nonmagnetic substrate and this nonmagnetic substrate, and show superparamagnetism, and this ground film.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the vertical-magnetic-recording medium which is applied to magnetic-recording media, such as computer circumference storage, a picture, and voice record, especially is recorded perpendicularly.
[0002]
[Description of the Prior Art] digitization of highly-efficient-izing of a computer in recent years, and a picture and voice, and high-definition-izing -- following -- especially -- fields, such as computer circumference storage (HDD), and a picture, a voice recording device (DVTR), -- setting -- a twist -- the magnetic-recording medium in which high-density record and reproduction are possible is required
[0003] For example, in the usual record within a field, by detailed-ization of a record bit, if it is going to realize high recording density, problems, like coercive force becomes high too much rather than the record ability of the heat fluctuation of record magnetization or a head will arise. In order to avoid these problems, the vertical magnetic recording using the perpendicular magnetic anisotropy films which have a perpendicular anisotropy is proposed in recent years.
[0004] The magnetic-recording medium used for such vertical magnetic recording usually consists of a soft-magnetism ground film and perpendicular magnetic anisotropy films prepared on it. Although the thing of high permeability and high saturation magnetic flux density was desirable as a soft-magnetism ground film, since a magnetic domain wall arose, there were problems, such as the instability of record magnetization, such as magnetic-domain-wall movement, generating of the spike noise by fluctuation of a magnetic domain wall and demagnetization of record resulting from magnetic-domain-wall movement by the external suspension magnetic field, and demagnetization.
[0005] As a measure for the problem of such a magnetic domain wall, the technology of obtaining the magnetic-recording medium which a magnetic domain wall does not generate is proposed by JP,11-149628,A by constituting a soft-magnetism ground film from granular structure which used the particle of a hard magnetic material. However, such a soft-magnetism ground film of composition has residual magnetization, in order for ordinary temperature to show a soft magnetism, and there was fault that a medium noise occurred, under the influence of this residual magnetization.
[0006]
[Problem(s) to be Solved by the Invention] this invention was made in view of the above-mentioned situation, and the 1st purpose is a low noise, and is to offer a vertical-magnetic-recording medium recordable high-density.
[0007] The 2nd purpose is a low noise, and is to offer vertical-magnetic-recording equipment recordable high-density.
[0008]
[Means for Solving the Problem] In the vertical-magnetic-recording medium possessing the ground film with which the vertical-magnetic-recording medium of this invention was formed on the nonmagnetic substrate and this nonmagnetic substrate, and the perpendicular magnetic layer formed on this ground film, the aforementioned ground film is characterized by consisting of layers which show superparamagnetism.
[0009] The driving means to which the vertical-magnetic-recording regenerative apparatus of this invention supports and drives [rotation] a vertical-magnetic-recording medium and the aforementioned vertical-magnetic-recording medium, The magnetic head which has an element for performing the element for recording information to the aforementioned vertical-magnetic-recording medium, and recorded informational reproduction, The carriage assembly which supported the aforementioned magnetic head free [movement] to the aforementioned vertical-magnetic-recording medium is provided. the aforementioned vertical-magnetic-recording medium It is characterized by providing the ground film which consisted of layers which are formed on a nonmagnetic substrate and this nonmagnetic substrate, and show superparamagnetism, and the perpendicular magnetic layer formed on this ground film.

[0010]
[Embodiments of the Invention] The vertical-magnetic-recording medium of this invention consists of a nonmagnetic substrate, a ground film, and a layered product containing a perpendicular magnetic layer, and the ground film consists of layers which show superparamagnetism.
[0011] Moreover, the vertical-magnetic-recording regenerative apparatus of this invention is what offers the vertical-magnetic-recording regenerative apparatus using the above-mentioned vertical-magnetic-recording medium. The above-mentioned vertical-magnetic-recording medium and the driving means which support and drive [rotation] this vertical-magnetic-recording medium, It has the magnetic head which has an element for performing the element for recording information to a vertical-magnetic-recording medium, and recorded reproduction of magnetic information, and the carriage assembly which supported the magnetic head free [movement] to the vertical-magnetic-recording medium.
[0012] Moreover, by very low temperature, magnetic properties show a soft magnetism, and, as for such a ground film, magnetic properties show a paramagnetism in ordinary temperature. It is known that the flux reversal time at the time of record is the order for about 10 to 8 seconds. Effective magnetic properties are not the magnetic properties near [which received heat fluctuation] ordinary temperature but magnetic properties which have not been influenced of heat fluctuation in this reversal time. Therefore, it is possible to consider that the magnetic properties by which magnetic measurement was carried out under low temperature in that it is not influenced of heat fluctuation are equivalent to the time of actual record, and it is possible to consider that the magnetic properties of the ground film in the very low temperature whose temperature T is 10K are the magnetic properties at the time of actual record.
[0013] Then, the ground film concerning this invention shows the magnetic properties of a soft magnetism preferably to the order whose flux reversal speed by the recording head magnetic field is 10 to 8 seconds, and shows the magnetic properties of a paramagnetism in 1 seconds or more. Or the ground film concerning this invention is desirable, at least, temperature T shows the magnetic properties of a soft magnetism by 10K, and near ordinary temperature shows the magnetic properties of a paramagnetism.
[0014] Still more preferably, a ground film has saturation magnetization Ms below by impression magnetic field 3950 A/m (50 Oe) to the order for 10 to 8 seconds equivalent to recording head magnetic field reversal time, and magnetization is not saturated below with impression magnetic field 790000 A/m (10000Oe) to order 1 second or more.
[0015] Or still more preferably, temperature T has saturation magnetization Ms by below impression magnetic field 3950 A/m (50 Oe) or less by 10K, and, as for a ground layer, magnetization is not saturated near ordinary temperature below in impression magnetic field 790000 A/m (10000 Oe).
[0016] Thus, the ground film used for this invention acts as a soft-magnetism film at the time of record, and acts as a paramagnetism film at the time of reproduction. Although a steep record magnetic field is formed by this at the time of record, since there is little spontaneous magnetization at the time of reproduction, it does not become the generation source of noises, such as a spike noise, and is not influenced of an external suspension magnetic field.
[0017] Thus, according to this invention, the particle size of a magnetic particle can be moderately controlled so that the material which shows a soft magnetism is used for a ground film and superparamagnetism is originally shown, and the magnetic property at the time of record and reproduction can be changed using heat fluctuation.
[0018] The composition which consists of a particle of the grade which shows the superparamagnetism of soft magnetic materials, for example as desirable composition of the layer which shows the superparamagnetism which constitutes a ground film, or the composition which consists of granular structure by which the particle which shows the superparamagnetism of soft magnetic materials in a nonmagnetic base material was distributed is raised.
[0019] The composition which consists of a particle which shows the superparamagnetism of soft magnetic materials can be produced using the material system which has composition which the microcrystal grain of soft magnetic materials distributed in amorphous materials, such as FeTaN, FeAlN, and FeZrN.
[0020] the composition which consists of granular structure by which the particle which shows the superparamagnetism of soft magnetic materials in nonmagnetic base materials, such as an oxide and a nitride, was distributed -- a nonmagnetic base material and soft magnetic materials -- for example, duality -- it can produce by carrying out a spatter using a simultaneous spatter etc.
[0021] Moreover, as for the particle size of the particle which shows the superparamagnetism, in this invention, it is desirable that it is 40nm or less.
[0022] Moreover, it is possible to suppress the eddy current generated in the case of RF record by using as a high resistance film the film in which superparamagnetism is shown.
[0023] As a method of forming the perpendicular magnetic layer concerning this invention on a ground film or a nonmagnetic substrate, physical vapor depositions, such as a spatter, a vacuum deposition method, a spatter in gas, and the gas flow spatter method, are used, for example. The ferromagnetic material which contains at least a kind of element chosen from Co, Fe, and nickel at least as the magnetic substance, for example, CoPtCr, CoCrTa, CoTaPt, CoNiTa,

CoPt, CoPtCr, etc. are used.
[0024] The soft magnetic materials which contain at least a kind of element chosen from Co, Fe, and nickel at least as a material used for the layer which shows the superparamagnetism of a ground film, for example, CoFe, NiFe, CoZrNb, FeZrN, FeTaN, etc. are used.
[0025] Moreover, in the case of granular structure, non-magnetic metal, such as Ag, Ti, Ru, and C, the compound of those or an oxide, a nitride, a fluoride, carbide, for example, SiO2 and SiO, Si3N4, aluminum2O3, AlN, TiN, BN, CaF, TiC, etc. can be used as a nonmagnetic base material.
[0026] Moreover, a ground film may contain the arbitrary interlayers prepared between the layers which show a nonmagnetic substrate and superparamagnetism, or between the layers which show a perpendicular magnetic layer and superparamagnetism.
[0027] As such an interlayer, RuTi or RuCr, TiN, etc. can be used, for example.
[0028] If the above interlayers are used between the layers which show a nonmagnetic substrate and superparamagnetism, with reference to the following and the drawing which can control the particle size and the perpendicular stacking tendency of the crystallinity of the magnetic layer formed on it, and a magnetic particle, this invention will be explained more concretely.
[0029] Drawing 1 shows drawing for explaining the composition of the magnetic-recording medium of this invention.
[0030] The magnetic-recording medium concerning this invention has the structure which carried out the laminating of the ground film 2 and magnetic layer 3 which consisted of layers which show superparamagnetism on the nonmagnetic substrate 1 so that it may illustrate.
[0031] A nonmagnetic substrate can use for example, a glass-ceramics substrate, a tempered glass substrate, etc.
[0032] By this magnetic-recording medium, the ground film 2 may be first formed of the DC magnetron-sputtering method in inert gas atmosphere, such as an argon, neon, and a xenon, on the nonmagnetic substrate 1, using the target which consists of soft magnetic materials which contain at least a kind of element chosen from Co, Fe, and nickel. Then, a magnetic layer 3 can be formed by the spatter in inert gas atmosphere using the target which consists of ferromagnetic material which contains at least a kind of element chosen from Co, Fe, and nickel on the obtained ground layer 2.
[0033] Drawing 2 shows the perspective diagram which understood a part of example of the magnetic recorder and reproducing device concerning this invention.
[0034] It has the composition shown in drawing 1 , the spindle 122 is equipped with the magnetic disk 121 of ****** for recording information, and a rotation drive is carried out at a fixed rotational frequency by the spindle motor which is not illustrated. The slider 123 in which the magnetic head which accesses a magnetic disk 121 and performs informational record reproduction was carried is attached at the nose of cam of a suspension 124 which consists of sheet metal-like flat spring. The suspension 124 is connected to the end side of the arm 125 which has the bobbin section holding the drive coil which is not illustrated etc.
[0035] The voice coil motor 126 which is a kind of a linear motor is formed in the other end side of an arm 125. The voice coil motor 126 consists of a drive coil which was able to be wound up in the bobbin section of an arm 125 and which is not illustrated, and a magnetic circuit constituted with the permanent magnet and opposite yoke which have been arranged as put it.
[0036] An arm 125 is held by the ball bearing which was prepared in two upper and lower sides of the fixed shaft 127 and which is not illustrated, and a rotation opposite rocking drive is carried out with a voice coil motor 126. That is, the position of the slider 123 on a magnetic disk 121 is controlled by the voice coil motor 126. In addition, 128 show the lid among drawing 2 .
[0037]
[Example] The schematic diagram with which an example of the magnetic-recording medium concerning this invention is expressed to example 1 drawing 3 is shown.
[0038] On the 2.5 inch glass substrate, the lubricant layer which produces a film continuously and does not illustrate the soft-magnetism layer 20 and interlayer 30 who show superparamagnetism for the magnetic-recording medium 70 which has composition as follows, a magnetic film 40, and the C protective coat 50 at the end was formed with the DIP coat so that it might illustrate, and the magnetic-recording medium shown in drawing 3 was produced. The soft-magnetism layer 20 and an interlayer 30 are constituted as a ground layer 60.
[0039] First, Ru system interlayer 30 was similarly formed except using Ru target on the soft-magnetism layer 20 which shows the superparamagnetism of the FeTaC system which obtained the soft-magnetism layer 20 which shows superparamagnetism as a ground film 60 by producing a FeTaC system target by the DC magnetron-sputtering method in Ar gas atmosphere, next was obtained.
[0040] On the obtained interlayer 30, the CoPtCr system target was similarly produced by the DC magnetron-sputtering method in Ar gas atmosphere which carried out minute amount addition of the oxygen, and the magnetic layer 40 was

obtained.
[0041] Thickness of above-mentioned each class was taken as 500nm of ground films, 20nm of interlayers, and 25nm of magnetic layers, respectively. Moreover, on the magnetic layer 40, 10nm spatter of the carbon was similarly carried out as a protective coat 50, and Sample A was obtained.
[0042] In addition, in order to sample A Set and to investigate the property of a soft-magnetism layer, the sample of only a soft-magnetism layer was also produced.
[0043] About the obtained sample A, a saturation magnetic field (Hc) and saturation magnetic flux density (Bs) were measured under the conditions from low temperature to near ordinary temperature, using SQUID (Superconducting Quntum Interherence Device) as the magnetic properties.
[0044] Moreover, S/N characterization (400kfci (flux change per inch)) of a sample was performed by 18nm of flying heights using the spin stand using the GMR head with 0.15 micrometers [of reproduction gap lengths], and a regenerative-track width of face of 0.8 micrometers, and the single magnetic pole type head with 0.4 micrometers [of main pole thickness], and a recording track width of face of 2 micrometers. the electromagnetism of a soft-magnetism layer -- in transfer characteristic evaluation, the size of DC noise (Ndc) and the existence of a spike noise were investigated
[0045] The obtained result is shown in the following table 1.
[0046] Using a 2.5 inch glass-ceramics substrate as the example 1 of comparison, and a substrate, immediately after soft-magnetism layer film production, it annealed for 5 minutes at 400 degrees C, and after leaving it in several minute Ar gas, Sample B was produced like Sample A except producing an interlayer and a magnetic layer.
[0047] In addition, also in Sample B, in order to investigate the property of a soft-magnetism layer, the sample of only a soft-magnetism layer was also produced.
[0048] the obtained magnetic-recording medium sample -- the magnetic properties and a soft-magnetism layer sample -- electromagnetism -- transfer characteristic evaluation was measured like the example 1
[0049] The result is shown in the following table 1.
[0050] A FeZr system target is used for example of comparison 2 pan instead of a FeTaC system target. 500nm of soft-magnetism layers which have the superparamagnetism of a FeZrN system by the DC magnetron-sputtering method in N2+Ar mixed-gas atmosphere is formed. The CoCrPt system target was used as a magnetic layer immediately after annealing this, 25nm of CoCrPt system magnetic layers was similarly formed in Ar gas atmosphere, the protective coat was further formed like Sample C, and the sample was produced.
[0051] the obtained magnetic-recording medium sample -- the magnetic properties and a soft-magnetism layer sample -- electromagnetism -- transfer characteristic evaluation was measured like the example 1
[0052] The result is shown in the following table 1.
[0053] Using a FeZr system target as an example 2 soft-magnetism layer, the film was produced in the mixed-gas atmosphere of O2 and Ar, and Sample D was produced like Sample A except producing the soft-magnetism layer which shows the superparamagnetism of the FeZrO system of high resistance.
[0054] In addition, in Sample D, in order to investigate the property of a soft-magnetism layer, the sample of only a soft-magnetism layer was also produced.
[0055] the obtained magnetic-recording medium sample -- the magnetic properties and a soft-magnetism layer sample -- electromagnetism -- transfer characteristic evaluation was measured like the example 1
[0056] The result is shown in the following table 1.
[0057] as an example 3 nonmagnetic substrate -- a 2.5 inch glass substrate -- using -- as a soft-magnetism layer -- a Co20Fe80 system target and Ti system target -- the inside of N2+Ar mixed-gas atmosphere -- duality -- after producing 25nm of CoFe-TiN granular soft-magnetism layers, carrying out a simultaneous spatter and making a substrate self-revolve around the sun, the interlayer, the magnetic layer, and the protective coat were formed like Sample A, and Sample E was obtained
[0058] In addition, in Sample E, in order to investigate the property of a soft-magnetism layer, the sample of only a soft-magnetism layer was also produced.
[0059] the obtained magnetic-recording medium sample -- the magnetic properties and a soft-magnetism layer sample -- electromagnetism -- transfer characteristic evaluation was measured like the example 1
[0060] The result is shown in the following table 1.
[0061]
[Table 1]

	磁気記録媒体の磁気特性				磁気記録媒体の電磁変換特性	
測定温度	10K		常温		常温	
サンプル	Hc (A/m)	Bs (T)	Hc (A/m)	Bs (T)	Ndc (μV_{rms})	S/Nm(dB)
A	79	1.8	0	-	4.2	26.5
B	63.2	1.7	39.5	1.5	6.2	23.1
C	237	1.6	79	1.4	5.9	24.4
D	55.3	1.2	0	-	4.0	27.3
E	79	0.8	0	-	3.9	26.5

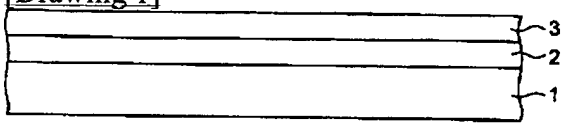
[0062] Moreover, the graphical representation which expresses the M-H magnetization curve of 10K, 100K, 200K, and 300K of Sample A to drawing 4 is shown respectively. The graph of 103,300K is shown [the graph of 10K / the graph of 101,100K] for the graph of 102,200K in 104 among drawing. In ordinary temperature, as for Sample A, it turns out that a paramagnetism is shown and Magnetization M is not saturated in the range more than 790000 A/m (10000 Oe), either so that it may illustrate. On the other hand, it turns out that it has [about 1] the saturation magnetization Ms near the square shape ratio in the case of low temperature, and the soft magnetism is shown.
[0063] Moreover, the samples B and C which annealed the soft-magnetism layer had saturation magnetization at all temperature, and showed the soft magnetism. It turns out that the other samples A, D, and E show the paramagnetism in ordinary temperature, and show the soft magnetism at low temperature, and the soft-magnetism particle shows the paramagnetism in response to the influence of heat fluctuation in the ordinary temperature neighborhood.
[0064] although every sample of S/N (henceforth S/Nm) of a medium is about good -- annealing -- the thing using the soft-magnetism layer showed the value small several dB the bottom the place which observed the noise signal with the oscilloscope although DC noise (Ndc) of the sample of only a soft-magnetism layer was good in general -- annealing -- although the spike noise was seen about the thing the bottom -- annealing -- a spike noise was hardly looked at by the sample of an except the bottom It is thought that S/Nm became small for this spike noise. For this reason, it turns out that the sample except having annealed has hardly affected a noise.
[0065] Furthermore, when the over-writing property was measured, it turns out that every sample shows the value of 30dB or more, and is recorded enough. Moreover, D50 showed 280kfci(s) or 300kfci(s), and the very good value with all samples.
[0066] Furthermore, although over-writing had fallen to about 20dB except Sample E when record frequency was made to increase to 600kfci(s) from 400kfci(s), Sample E was still value 30dB or more. Although the high resistance whose sample E is about 50 microomegam was shown when the electric resistance of a soft-magnetism layer was measured by the four probe method, number muomegam and the small value were shown except it. This is that the resistance of a soft-magnetism layer increased, and since it suppressed generating of the eddy current in a RF, it is considered that sufficient record was completed. Thus, by cheating out of the soft-magnetism layer which has superparamagnetism to high resistance, an over-writing property can consider as a high resolution medium good by RF record.
[0067] In Sample A, when the sample without Ru interlayer was produced and noise evaluation was carried out, the pulse width PW50 of a 30dB and a solitary-wave form was 14nm. [property / over-writing] Since the crystal growth of a magnetic layer is inadequate a little and this is a little inferior in magnetic property as compared with the case where there is an interlayer, it is considered that the low value was shown a little. Moreover, the sample without Ru interlayer was a value which does not change at all with Sample A about a noise.
[0068] As mentioned above, an example 1 or 3, and the examples 1 and 2 of comparison showed serving it as a paramagnetism at the time of reproduction, although the magnetic-recording medium concerning this invention plays the effective role as a soft magnetism by constituting a ground film from a soft-magnetism layer which shows superparamagnetism at the time of record, and not affecting generating of a noise at all.
[0069]
[Effect of the Invention] According to this invention, the noise by the residual magnetization and the magnetic domain wall at the time of the ordinary temperature of a ground film is suppressed, it is a low noise and a magnetic-recording medium recordable high-density can be offered.
[0070] Moreover, according to this invention, the noise by the residual magnetization and the magnetic domain wall at the time of the ordinary temperature of a ground film is suppressed, it is a low noise and a magnetic recording medium recordable high-density can be offered.

[Translation done.]

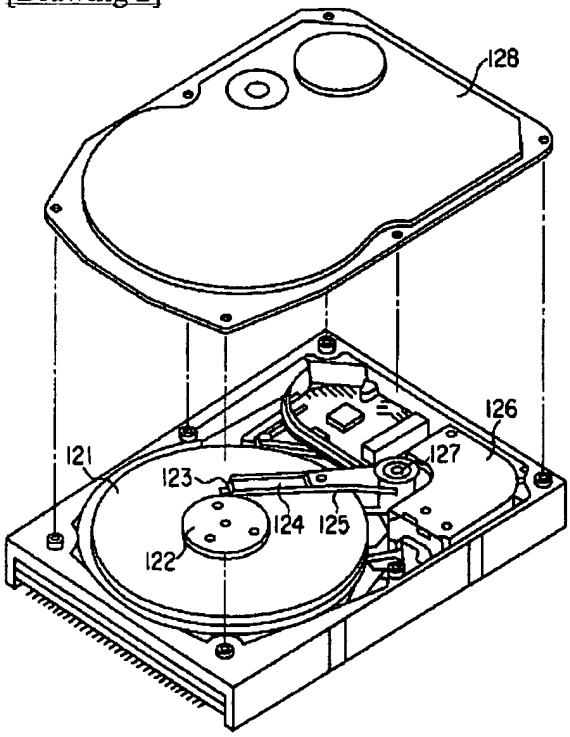
* NOTICES *

DRAWINGS

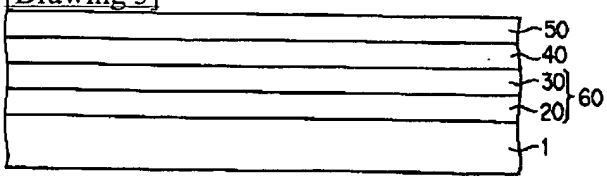
[Drawing 1]



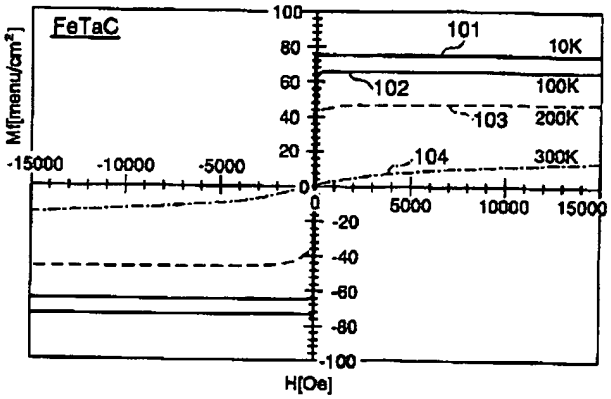
[Drawing 2]



[Drawing 3]



[Drawing 4]



[Translation done.]